Interferometric observations with IOTA and FLUOR

Michelson Summer School
May 2001 session

Flagstaff, Arizona

Vincent Coudé du Foresto
Observatoire de Paris
May 22nd, 2001

The four stages of an interferometric observation

- Observation preparation — Vincent Foresto (morning)

Lab session

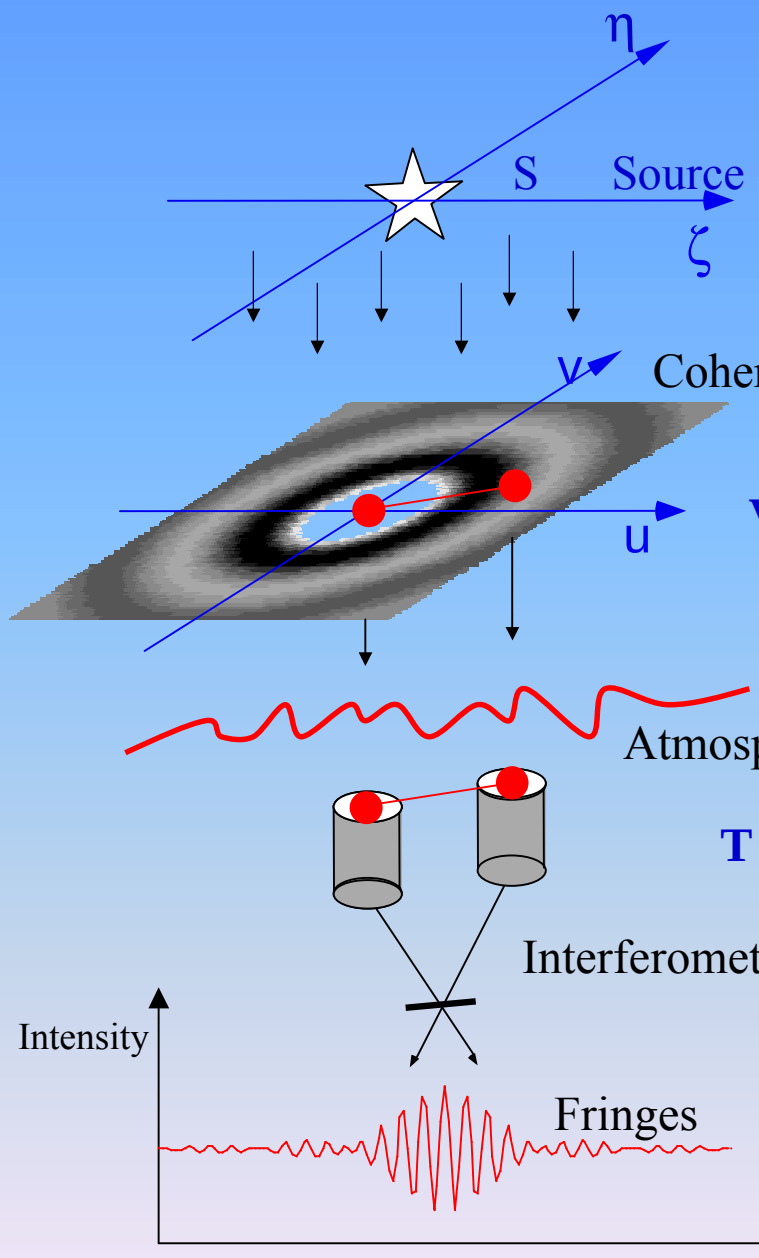
- Data acquisition — Vincent Foresto (morning)
- Data reduction — Guy Perrin (afternoon)

Lab session

- Data modelling and interpretation — Bertrand Mennesson (afternoon)

Lab session

Coherence and object visibility



$$\mathbf{V}(u,v) = TF\,[S(\eta,\zeta)]$$

$$\boldsymbol{\mu} = \mathbf{V} \cdot \mathbf{T}$$

From coherence factors to object visibilities

- Calibrator 1: $\mu_{cal1} \Rightarrow T_1 = V_{cal1} / \mu_{cal1}$
- Science target: $\mu^* \Rightarrow V^* = \mu^* \, . \, T$
- Calibrator 2: $\mu_{cal2} \Rightarrow T_2 = V_{cal2} / \mu_{cal2}$

Stellar interferometry is an art of calibration

A good calibrator is...

A source for which V can be predicted
(at the baseline considered)
with good accuracy and little bias

- Well modelled
- Well known
- Stable
- Observable with the same setup (Δm_K, λ_{eff} …)

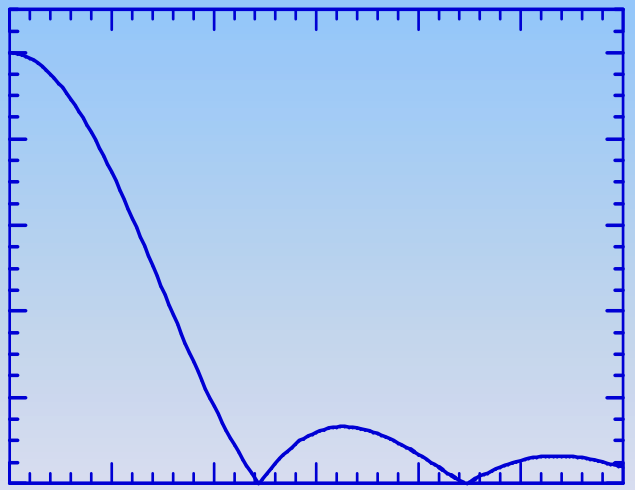
Common calibrator strategy

- Pick up a single star, non variable
- Use a uniform disk model
- Derive diameter from photometry (via T_{eff} and F_{bol})

Expected accuracy on ϕ_{UD} (not V!) :

- 5% in common cases
- 1% for photometric standards

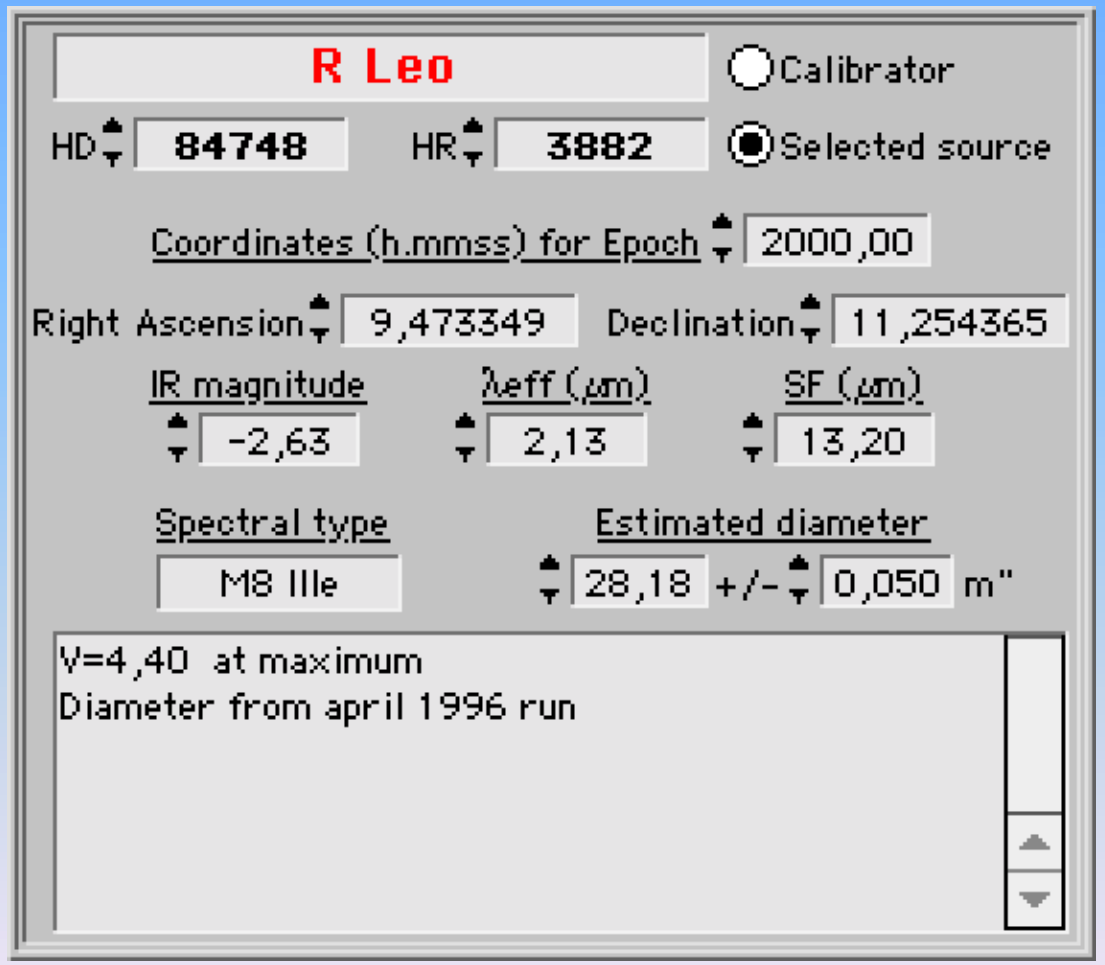
(cf. Cohen & al., A&A 117, 1864)



Other strategies are possible!

Diameter from photometry (demo)

Know thy sources!



- For a given observation, source status is either :

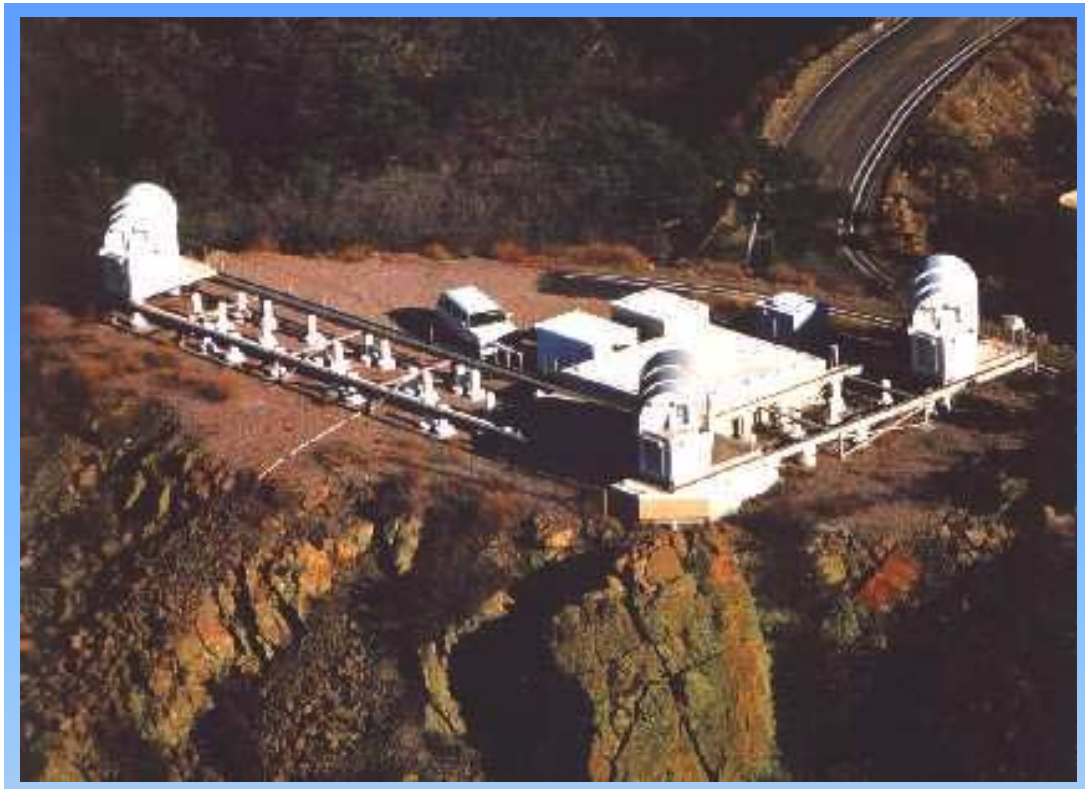
  Science target

  or

  Calibrator

- Source information is used for data reduction

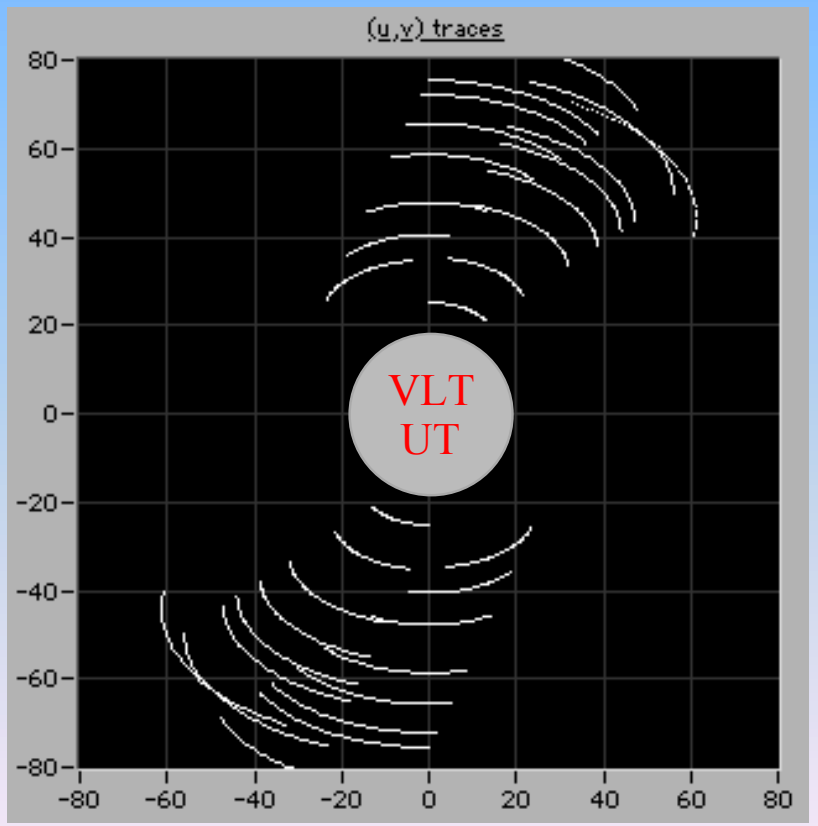
- Source ID needed for tracing correlations



Mont Hopkins
Arizona

IOTA

Infrared and Optical Telescope Array



- 2 (3) relocatable 45cm siderostats
- Minimum baseline: 7m
- Maximum baseline: 38m
- Interchangeable focal instruments
- Operative λ (FLUOR):
  - 2–2.4 μm (K band)
  - *3.4 – 4μm (L band)*

Relocating the telescopes

- Fixed stations prealigned with kinematic mounts
- Telescope relocated with its shelter building
- 2 or 3 hours afternoon work… when everything goes well

Plot (u,v) traces

(demo)

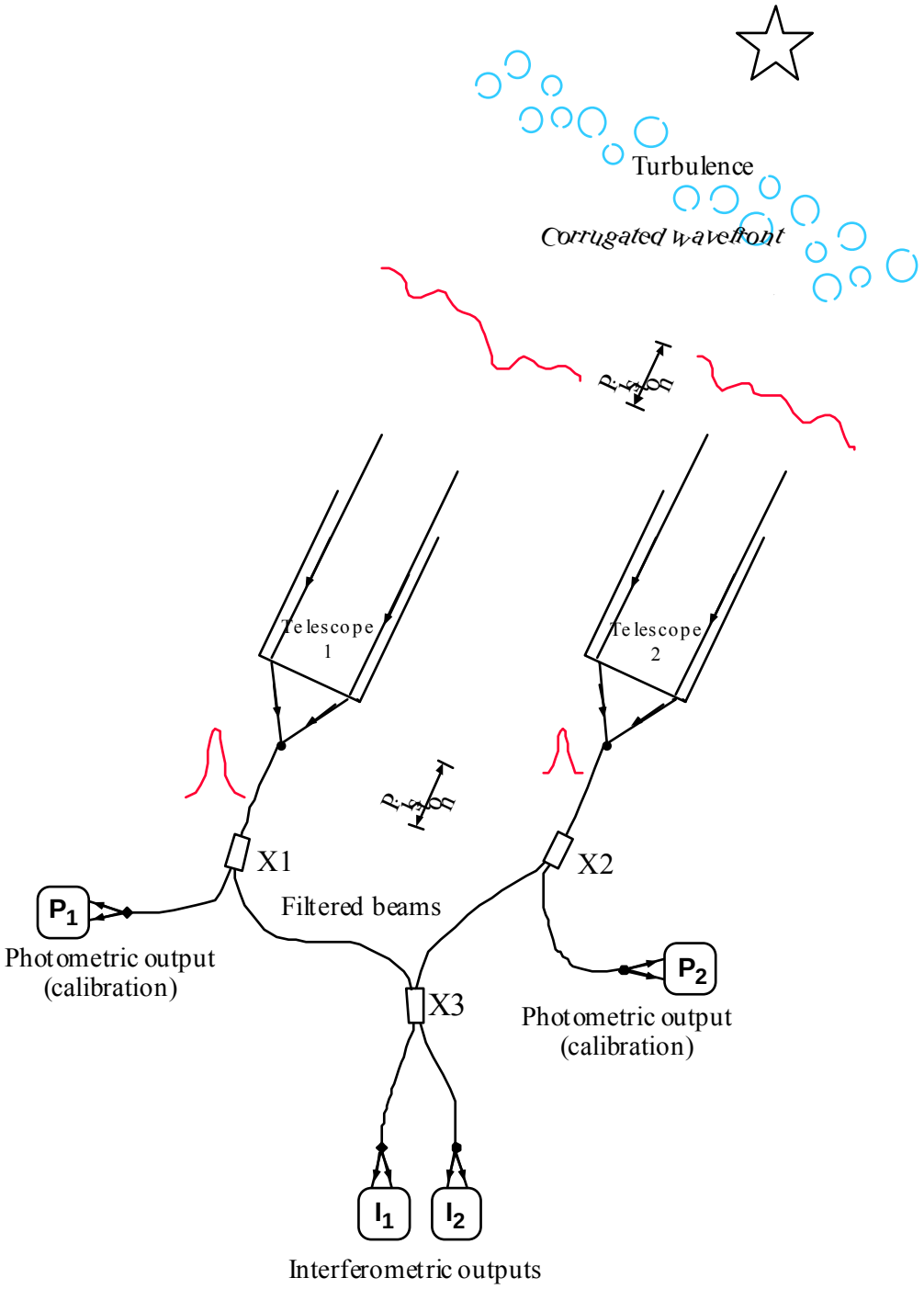
IOTA functional overview

- Beam collection: 45cm siderostats
  => *sky coverage limitations*
- Beam stabilization: fast tip-tilt
  => *limit magnitude V < 7*
- Beam transport: in vacuum pipes
- OPD equalization (rough): incremental long delay line
  => *need to delay either North or South telescope*
- OPD equalization (fine): continuous short delay line
  => *need to relocate long delay line every 2.3m in OPD*

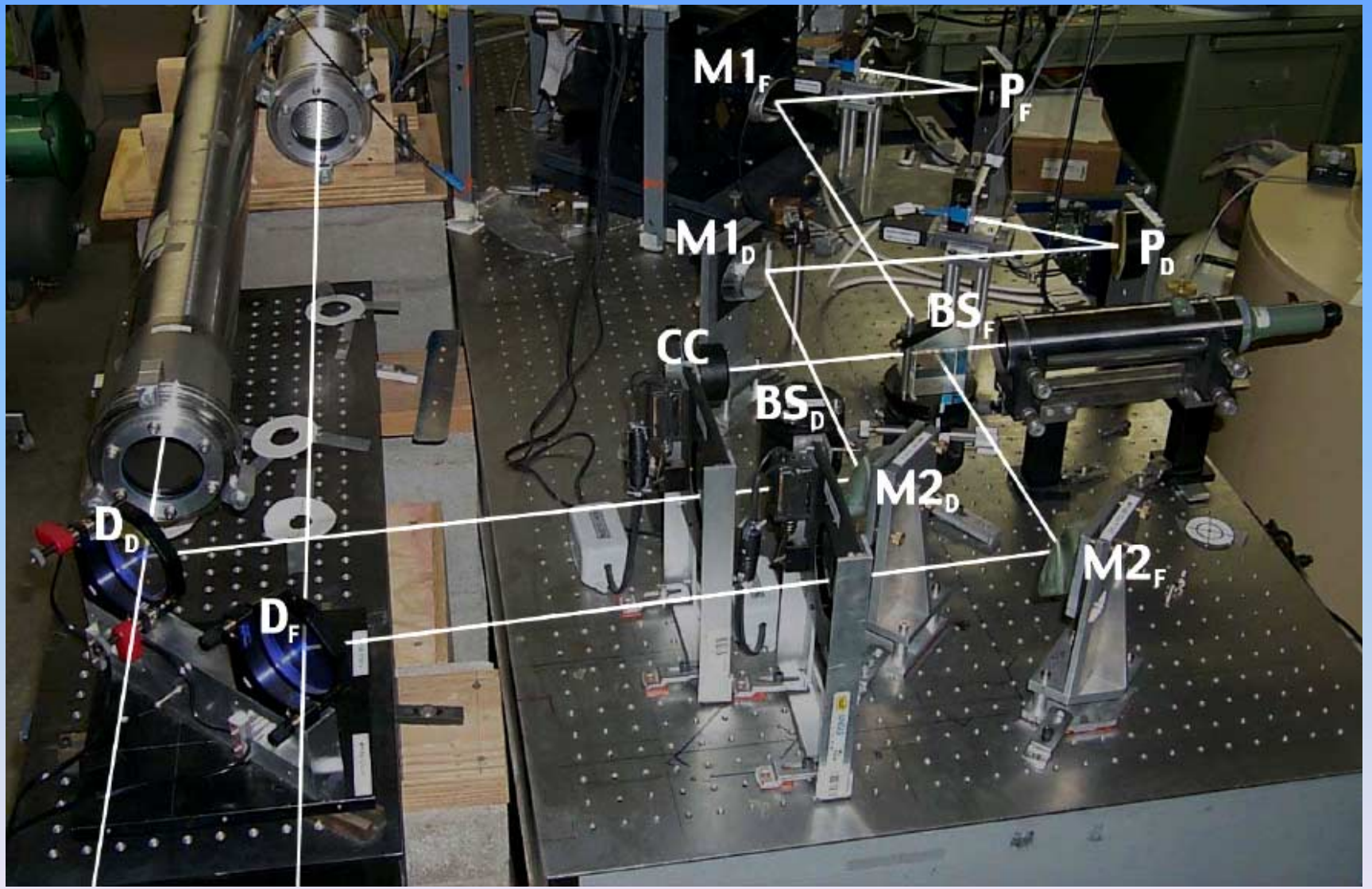
Plot observing schedule (demo)

FLUOR concept

- Two inputs:
  - Beam A and Beam B
- Single-mode fibers for:
  - « cleaning » of turbulent beams
  - Polarization control
  - beam combination (X-coupler)
- Coaxial beam combination
- Temporal OPD modulation
- Four outputs:
  - I_1, I_2, P_A and P_B



FLUOR layout



Optical pathlength difference modulation

- Temporal encoding through scanning mirror :

  $OPD = v_{scan} \cdot t$

- Maximum range :

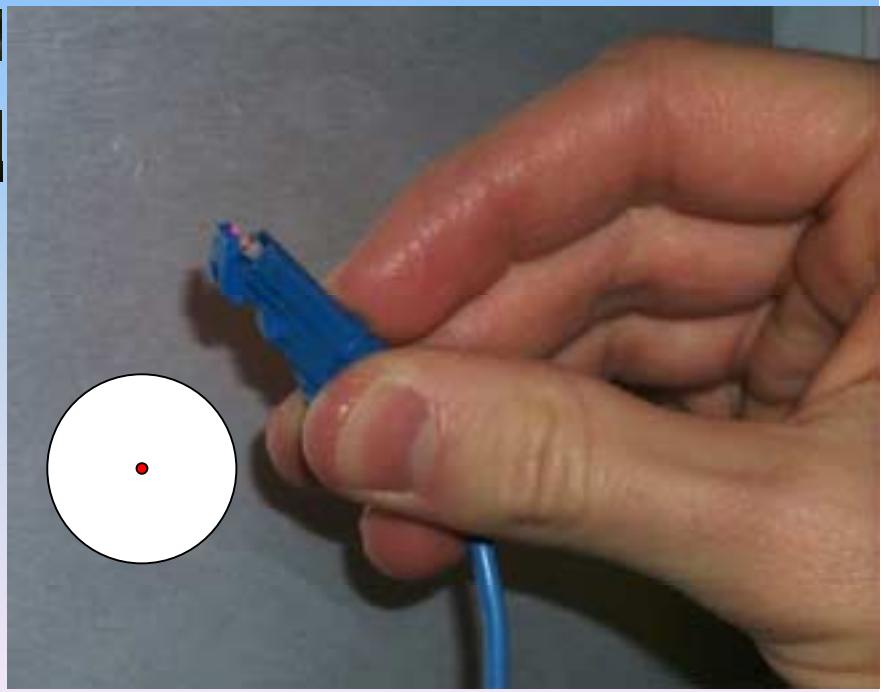
  $-90\mu m < OPD < +90\mu m$

- Scan velocity :

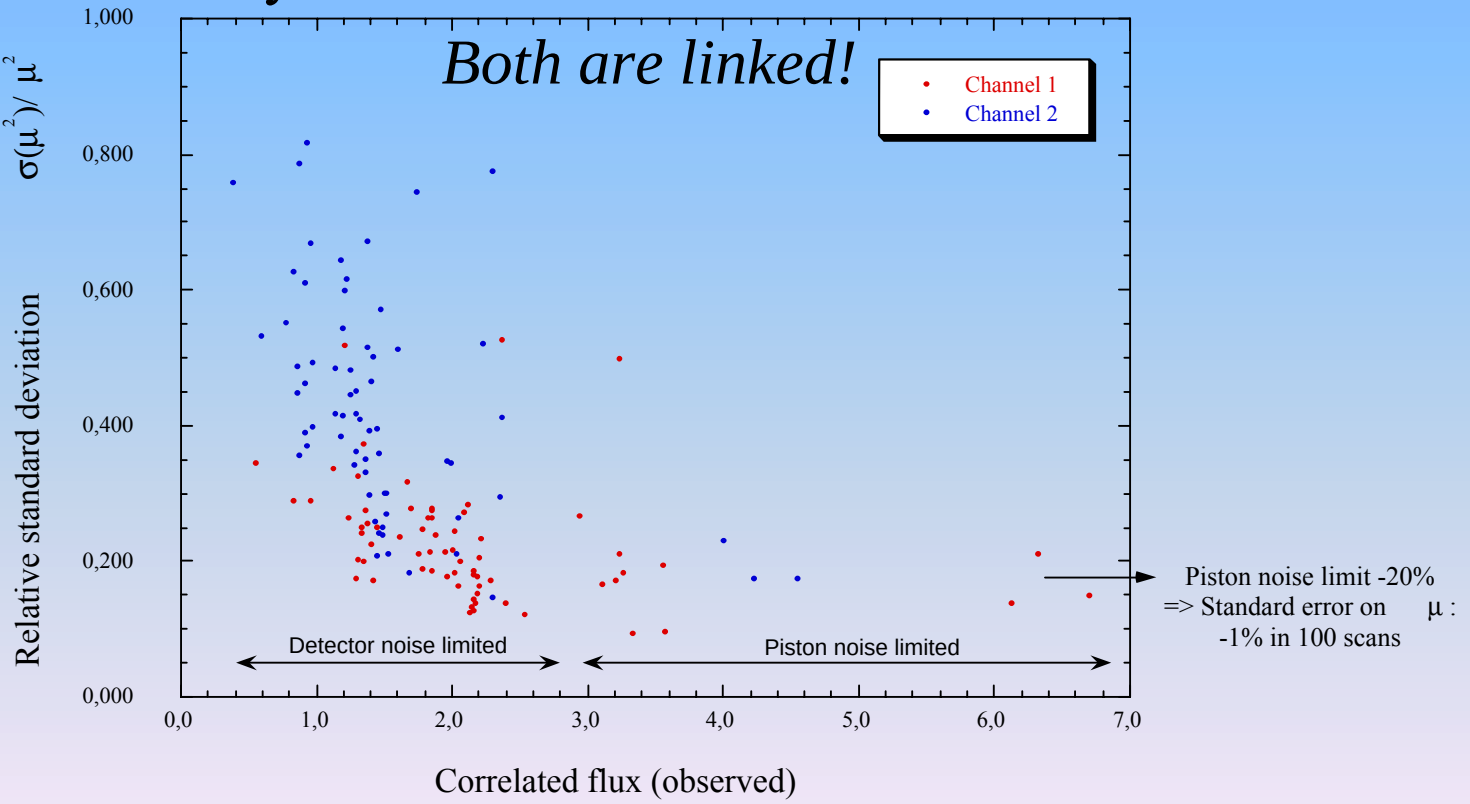
  $v_{scan} = 220 — 1100\mu m/s$

  $\Rightarrow f_{fringes} = 100 — 500Hz$

Guided optics components



- Single-mode waveguides
- Fluoride glass for IR transmission
- 9μm core, 125μm cladding
- $\lambda_c = 1.9\mu m$

FLUOR observational constraints

- Productivity : 4 – 6 sources / hour
- Limit magnitude : K ~ 4
- Typical accuracy : dV / V~ 1%